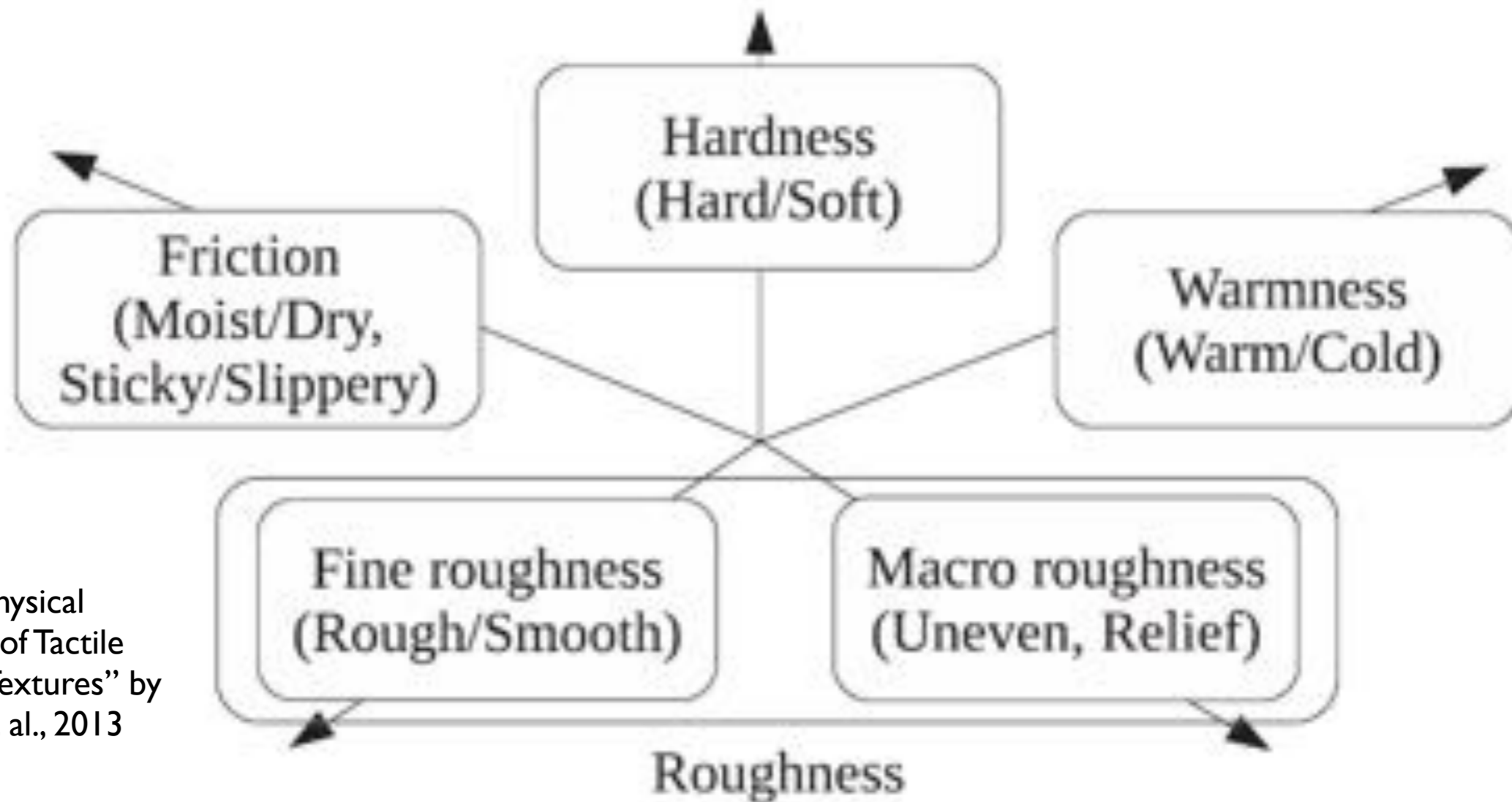# Lecture 5:
Tactile Haptic Devices

Allison M. Okamura
Stanford University

tactile feedback

- goal is to stimulate the **skin** in a programmable manner to create a desired set of sensations

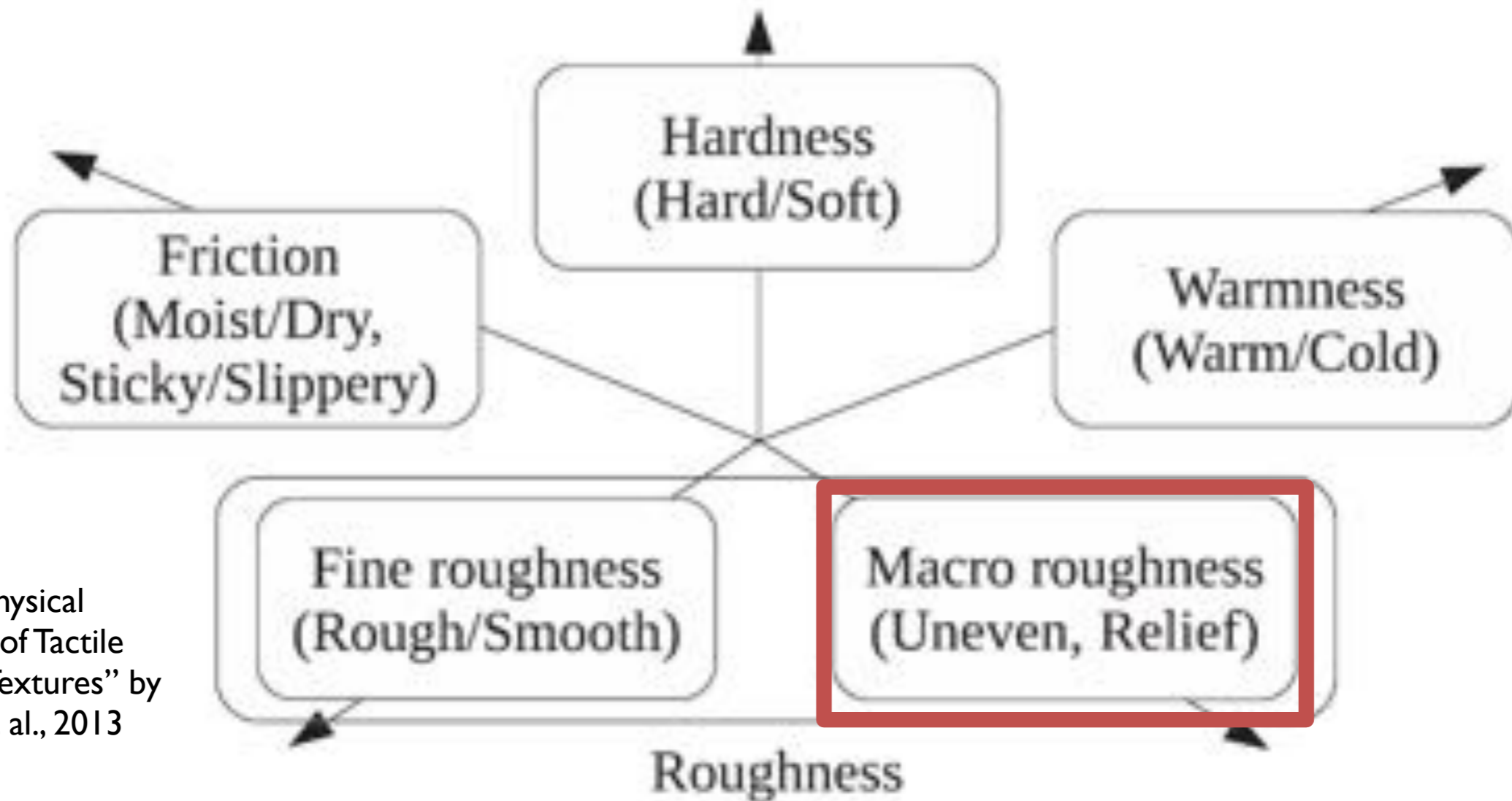- *sometimes* **distributed** tactile feedback is provided

What does the human hand feel?

Hardness
(Hard/Soft)

Friction
(Moist/Dry,
Sticky/Slippery)

Warmness
(Warm/Cold)

Fine roughness
(Rough/Smooth)

Macro roughness
(Uneven, Relief)

Roughness

"Psychophysical Dimensions of Tactile Perception of Textures" by Okamoto et al., 2013

What does the human hand feel?

Hardness
(Hard/Soft)

Friction
(Moist/Dry,
Sticky/Slippery)

Warmness
(Warm/Cold)

Fine roughness
(Rough/Smooth)

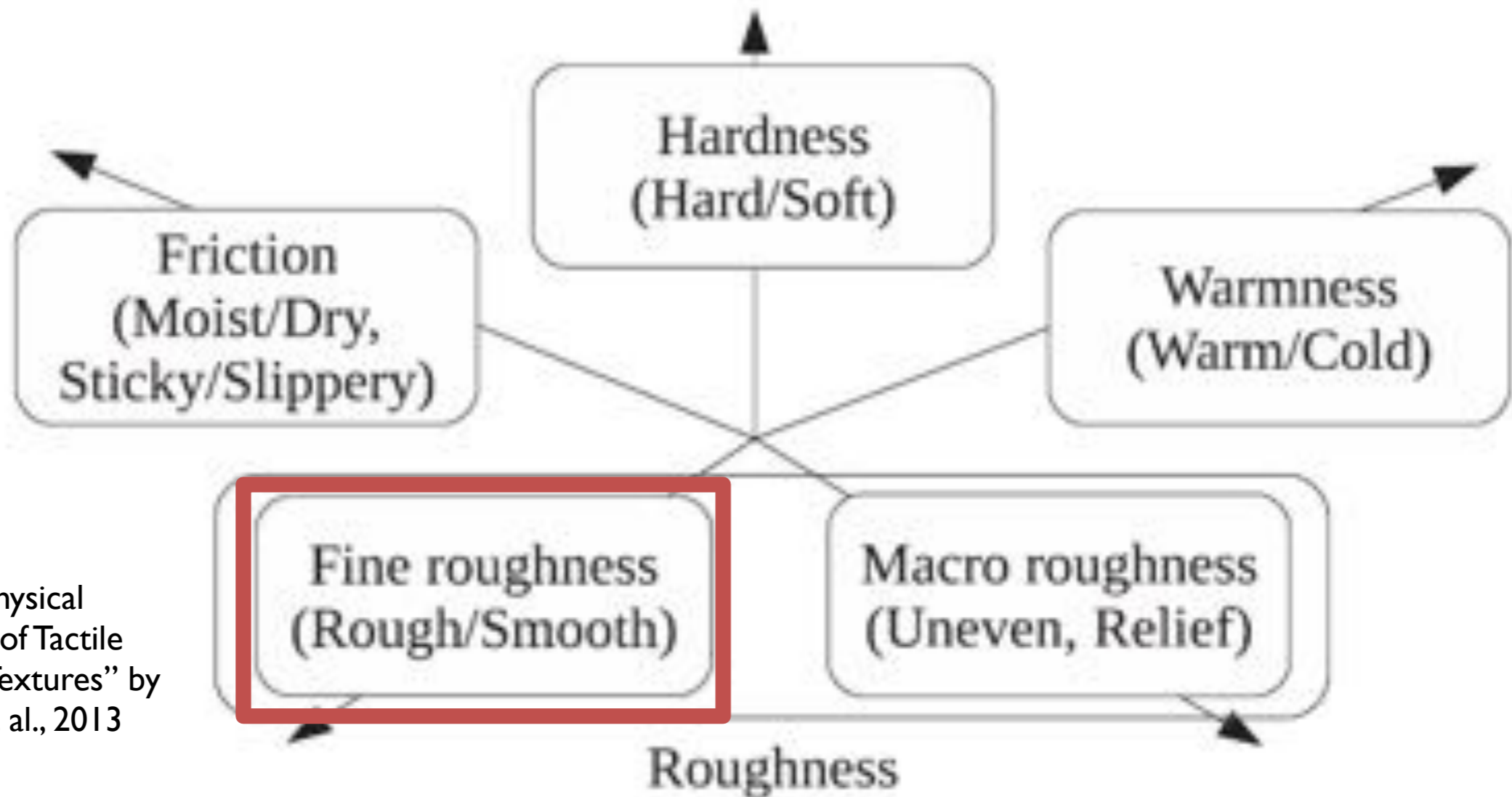Macro roughness
(Uneven, Relief)

Roughness

"Psychophysical Dimensions of Tactile Perception of Textures" by Okamoto et al., 2013

- Spatial distribution of SAI
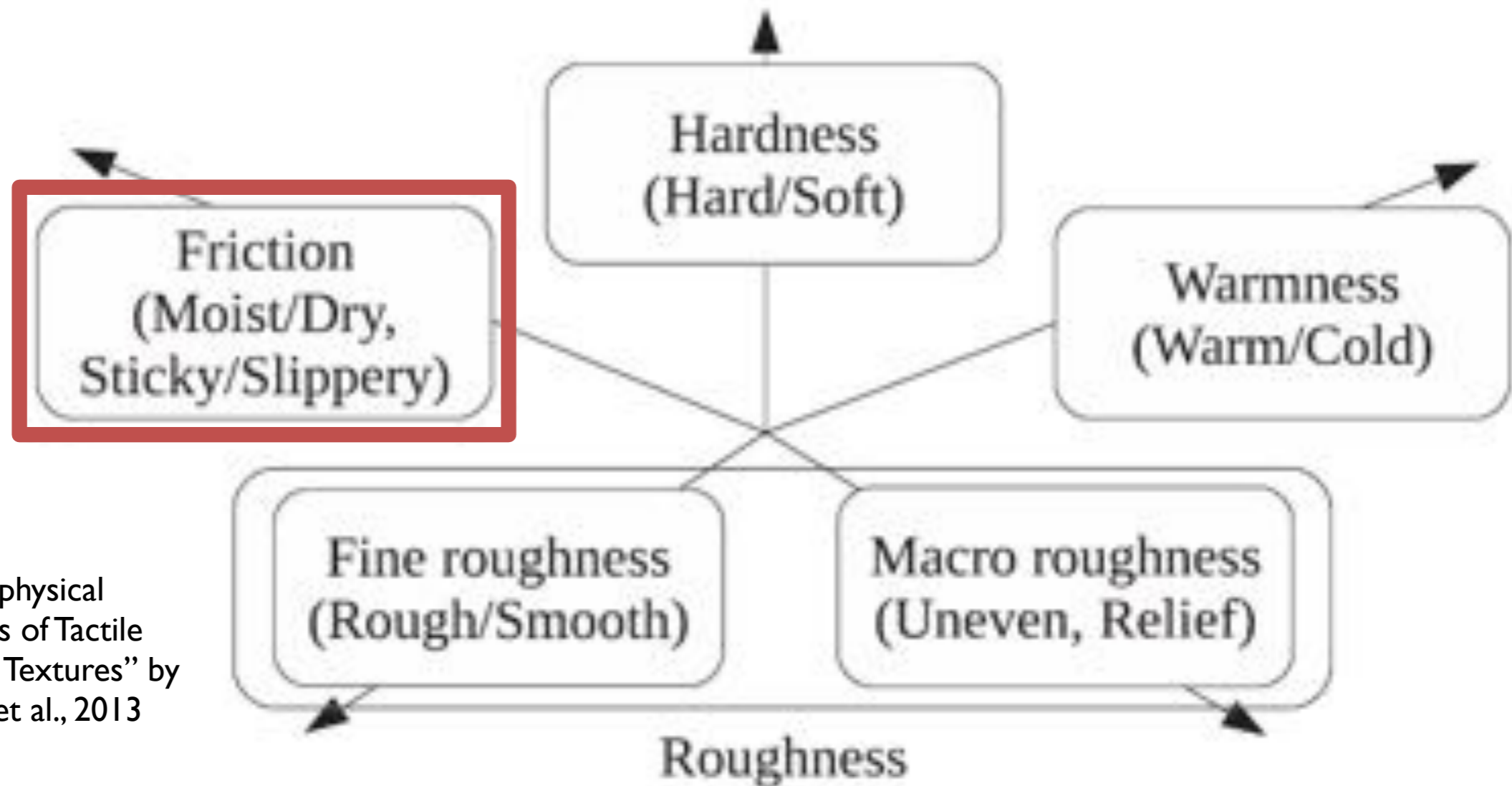- No temporal information

What does the human hand feel?

"Psychophysical Dimensions of Tactile Perception of Textures" by Okamoto et al., 2013

Hardness (Hard/Soft)

Friction (Moist/Dry, Sticky/Slippery)

Warmness (Warm/Cold)

Fine roughness (Rough/Smooth)

Macro roughness (Uneven, Relief)

Roughness

- Vibratory information
  - FAI and FAII

What does the human hand feel?

Hardness (Hard/Soft)

Friction (Moist/Dry, Sticky/Slippery)

Warmness (Warm/Cold)

Fine roughness (Rough/Smooth)

Macro roughness (Uneven, Relief)

Roughness

"Psychophysical Dimensions of Tactile Perception of Textures" by Okamoto et al., 2013

- Mediated by skin of finger pad
- Skin stretch or adhesion

What does the human hand feel?

Hardness
(Hard/Soft)

Friction
(Moist/Dry,
Sticky/Slippery)

Warmness
(Warm/Cold)

Fine roughness
(Rough/Smooth)

Macro roughness
(Uneven, Relief)

Roughness
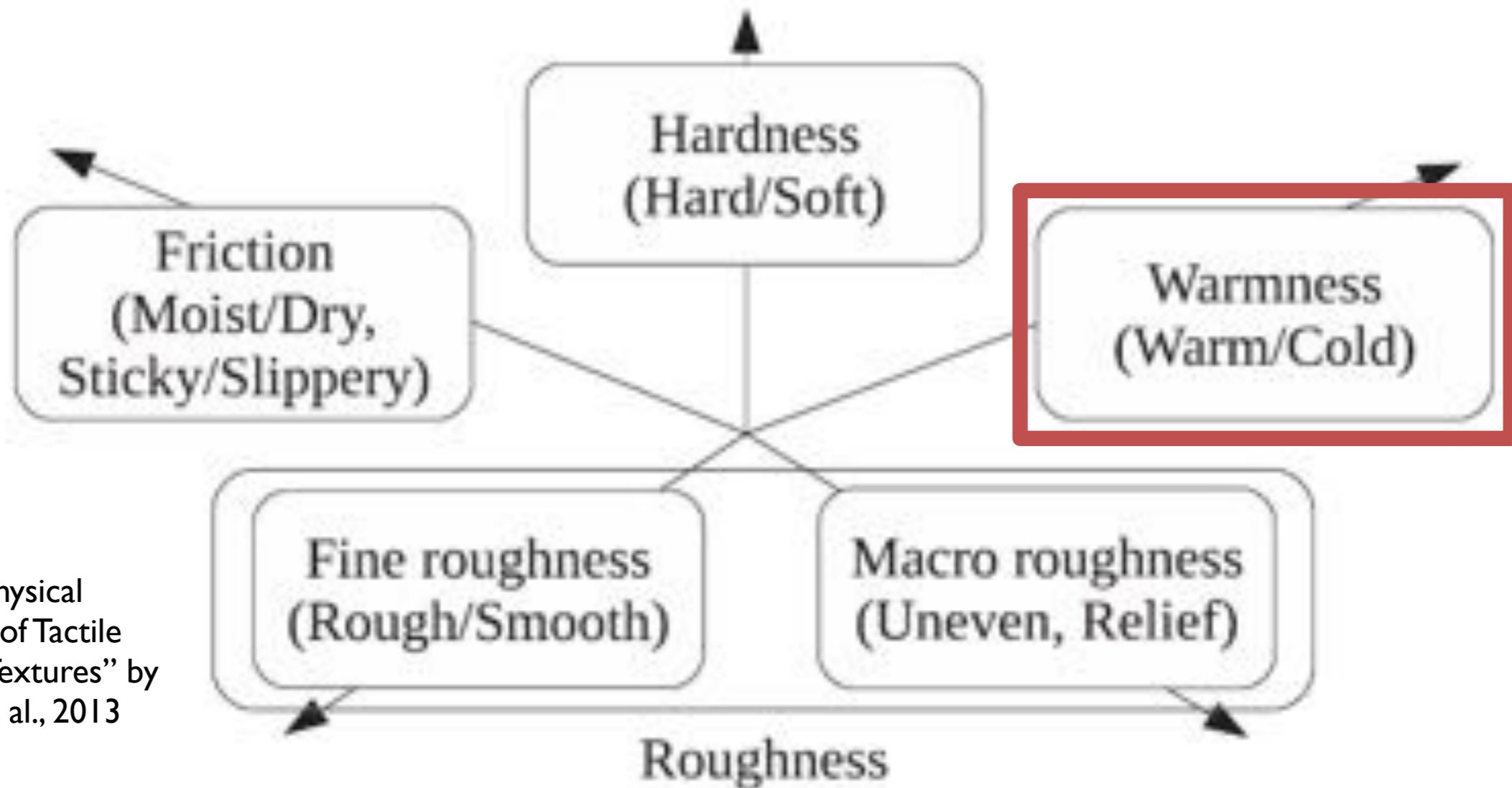
"Psychophysical Dimensions of Tactile Perception of Textures" by Okamoto et al., 2013

- Heat transfer property between texture and finger
- TRP ion-channels on free nerve endings

What does the human hand feel?
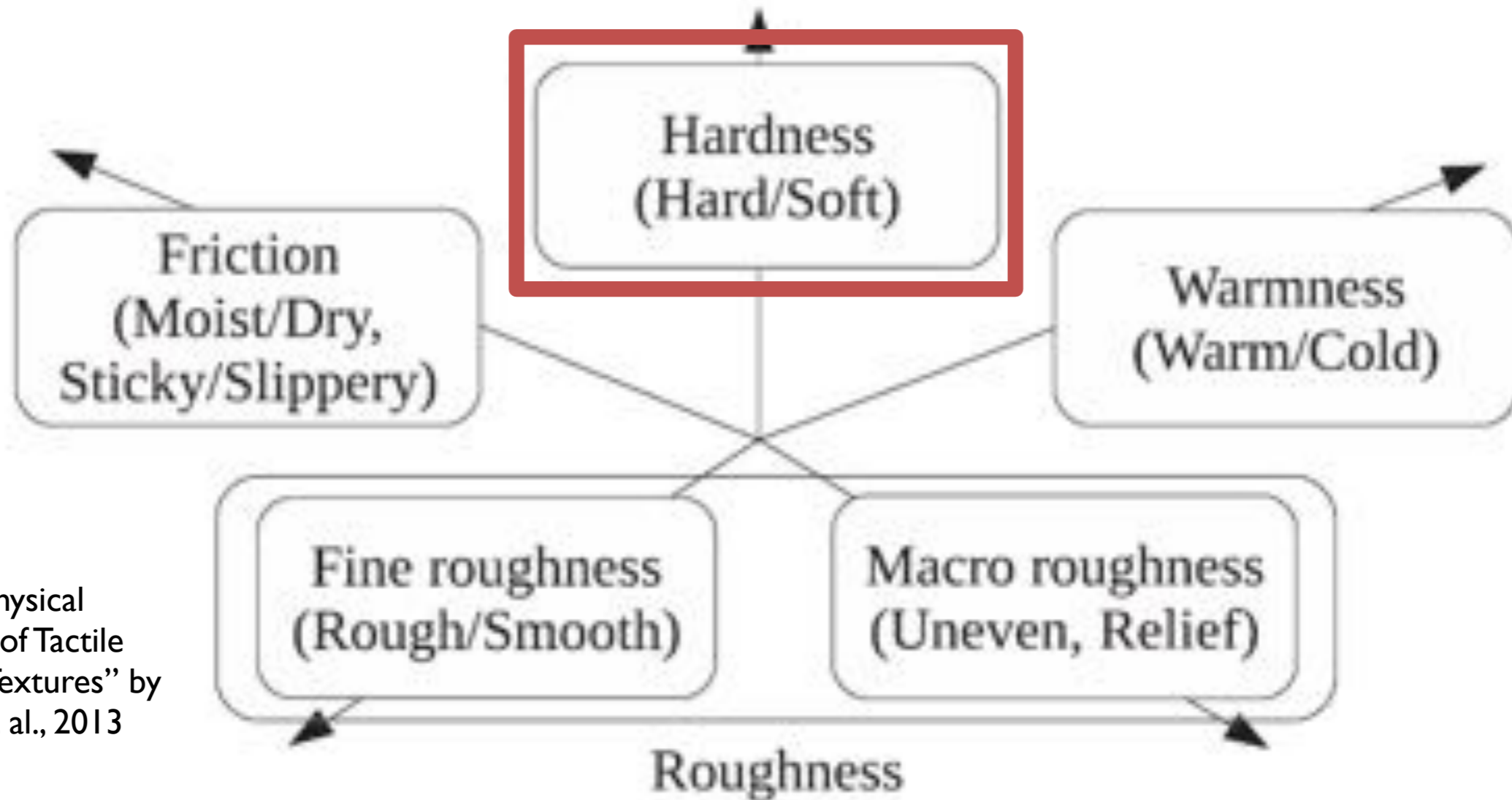
"Psychophysical Dimensions of Tactile Perception of Textures" by Okamoto et al., 2013

- Tactile cues
- Contact area between finger pad and object is important

Feeling through a tool

- Rigid link between surface and fingers

- No spatial cues available
  - Skin deformation from tool, not from surface

- Vibratory stimuli

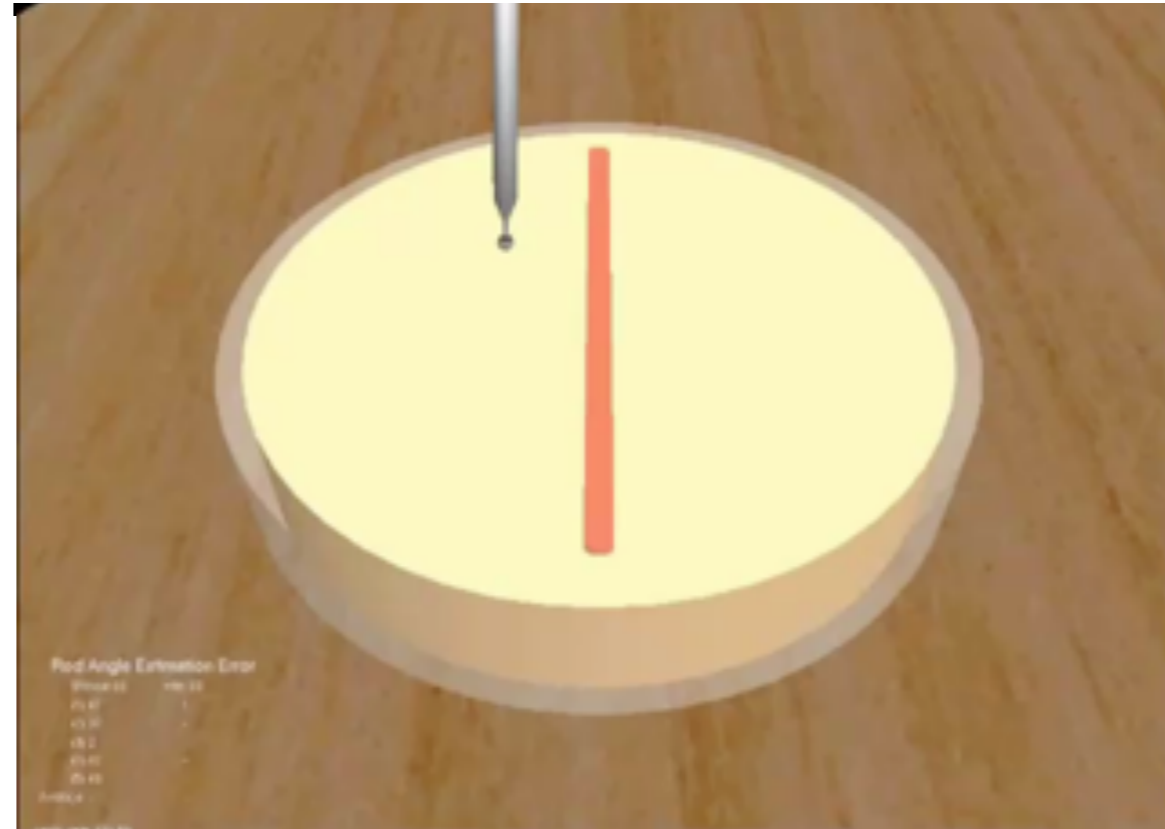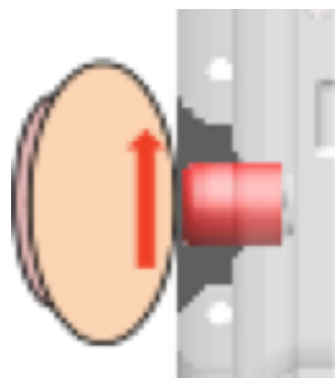- Warm/cool dimension cannot be conveyed

ME 327: Design and Control of Haptic Systems

technologies and interaction modes
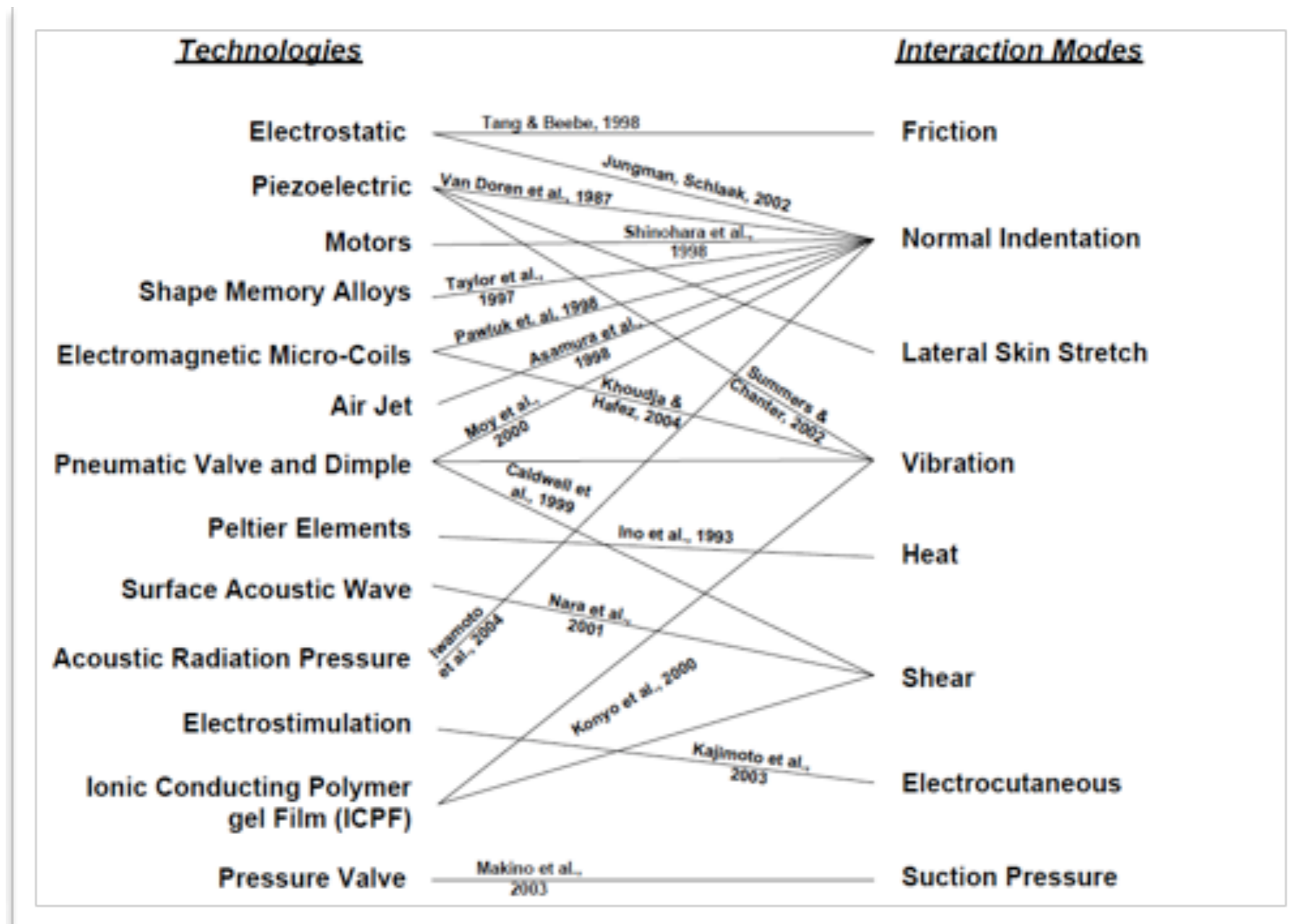
Jerome Pasquero, Survey on Communication through Touch, Technical Report: TR-CIM 06.04, 2006

particle jamming
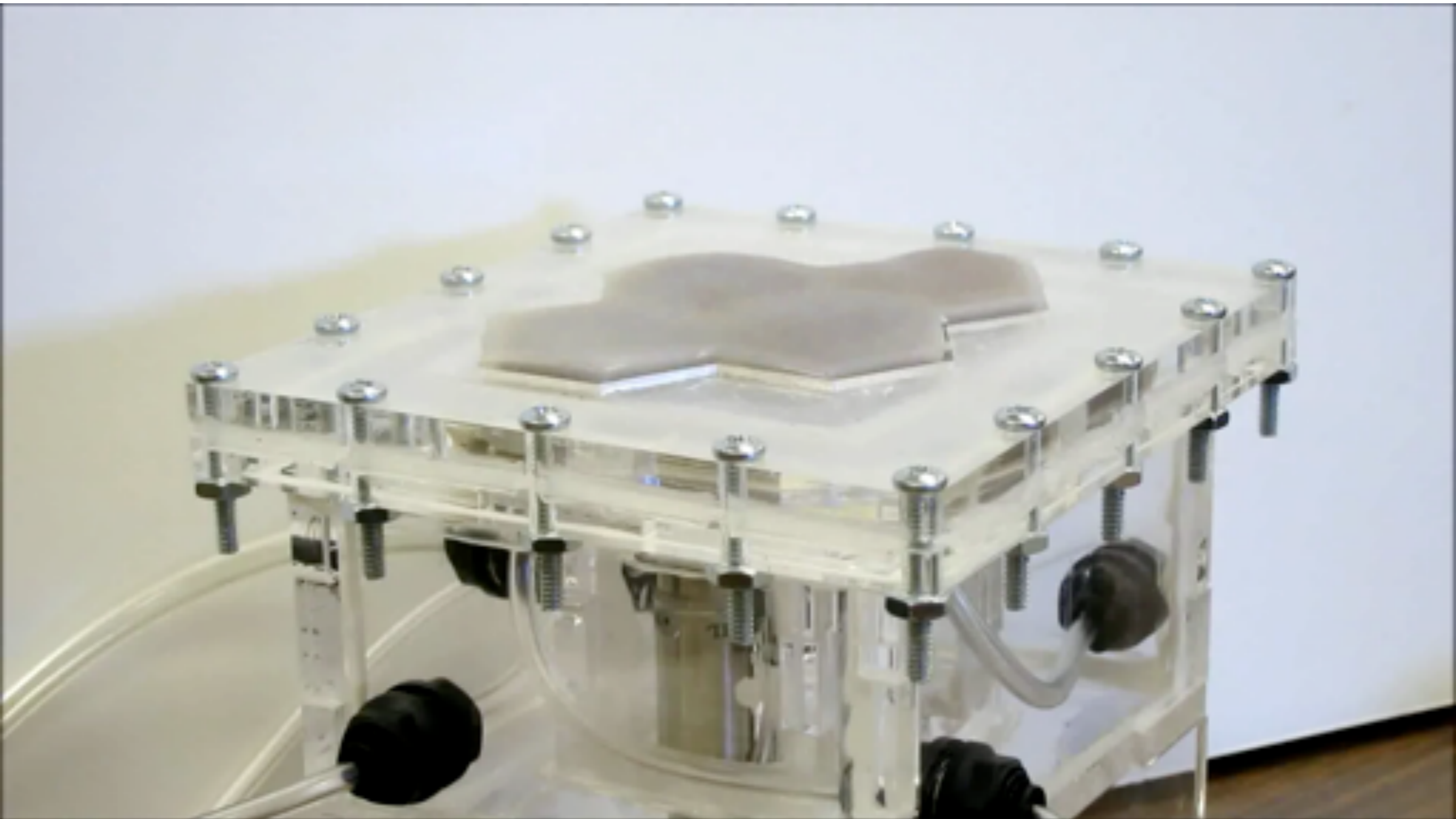
Stanley et al. 2013

skin stretch
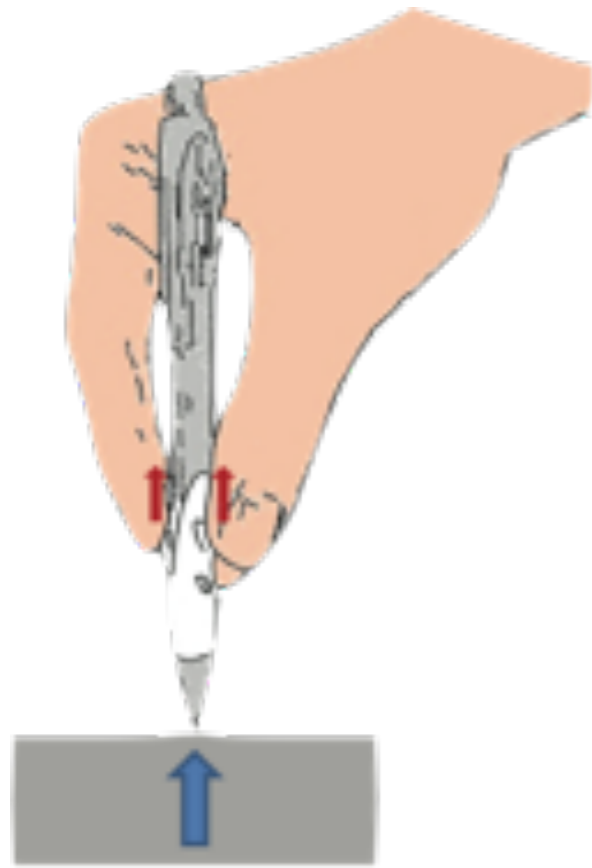
Quek et al. 2013, Schorr et al. 2013
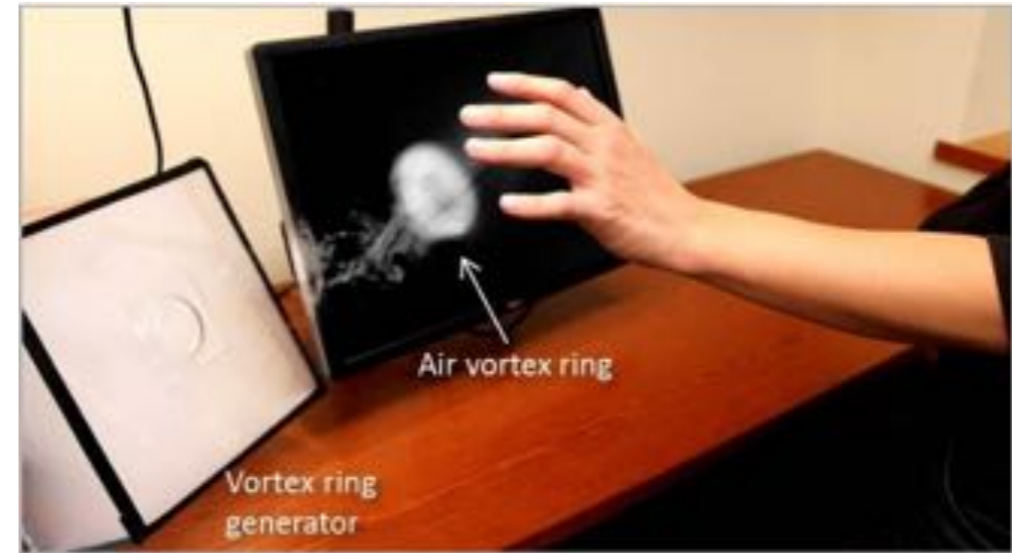
variable friction surfaces
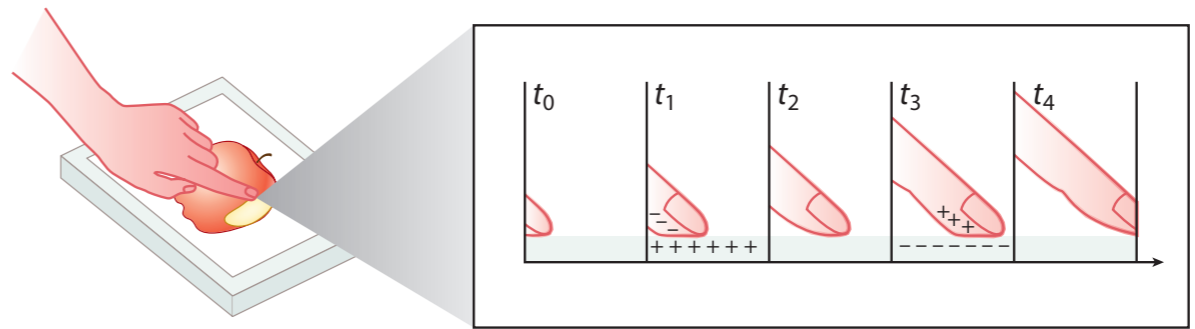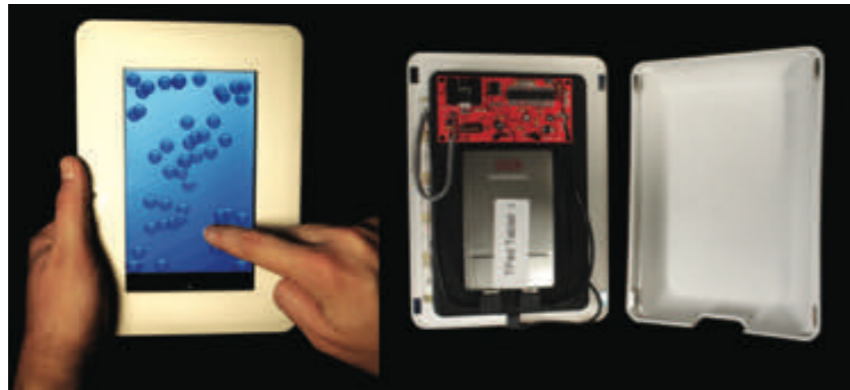
Northwestern TPad (many publications):
http://stage-admin.northbynorthwestern.com/story/more-than-a-feeling/

Disney's TeslaTouch (Bau et al. 2011):
https://www.youtube.com/watch?v=3l3MDNZk-3l

mid-air haptics

Ultrasonic haptics (Ultrahaptics):
https://www.youtube.com/watch?v=6lhQnWb44zk

Vortex haptics (Microsoft):
https://www.youtube.com/watch?v=b5vzvMCmiyQ

vibration feedback

eccentric mass motors

www.precisionmicrodrives.com

4 mm, ~0.6 g

7 mm, ~1 g

12 mm, ~1.2 g
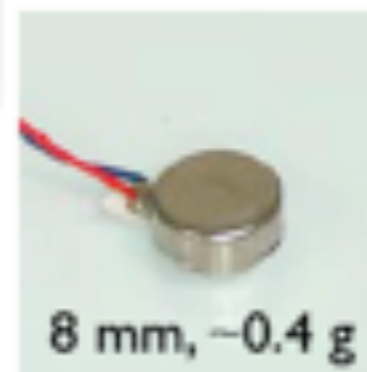
20 mm, ~4 g

24 mm, ~2.8 g
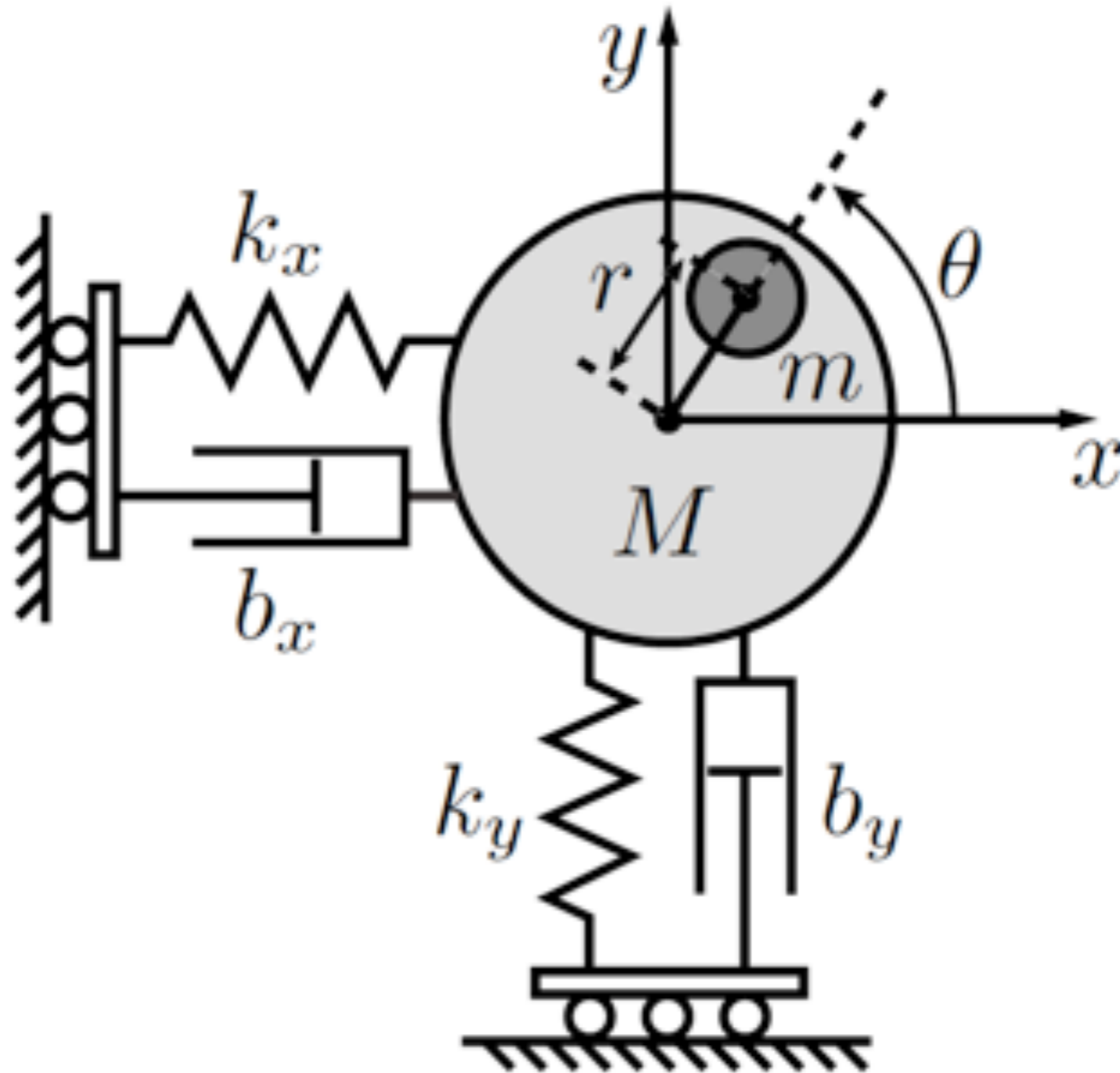
45 mm, ~9.7 g

shaftless vibration motors

10 mm, ~0.8 g

www.precisionmicrodrives.com

Three pole DC motor
with eccentric coil

8 mm, ~0.4 g   12 mm, ~0.9 g   12 mm, ~0.6 g

vibration motors

ME 327: Design and Control of Haptic Systems
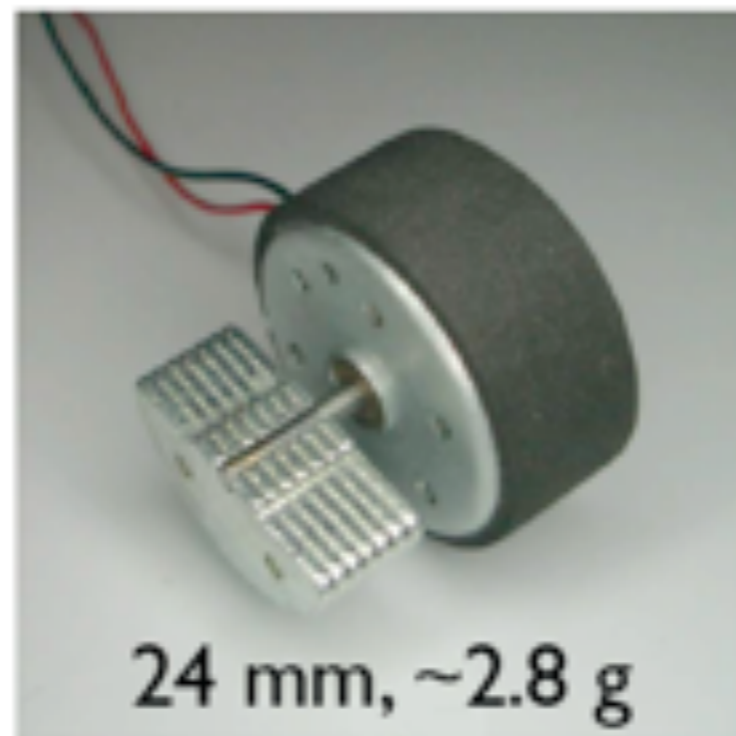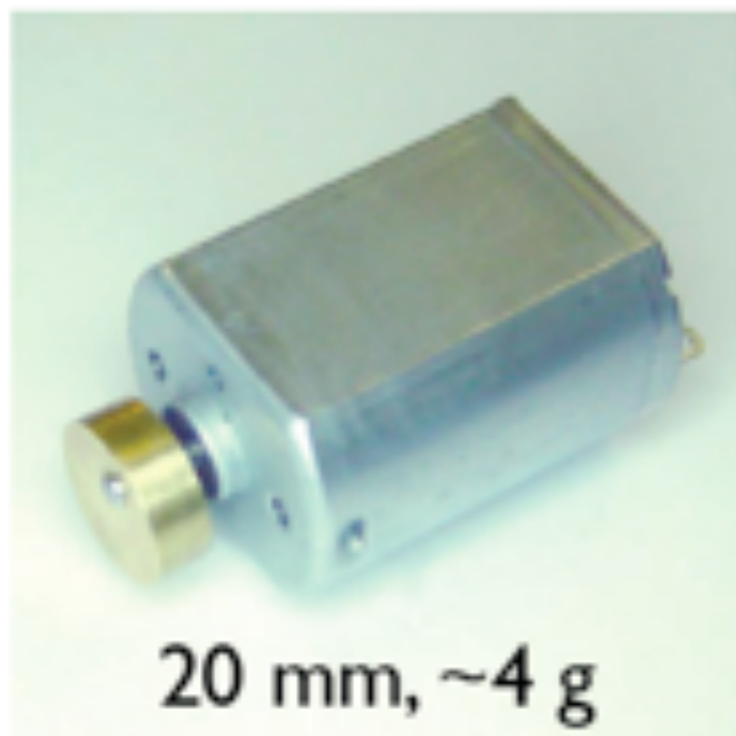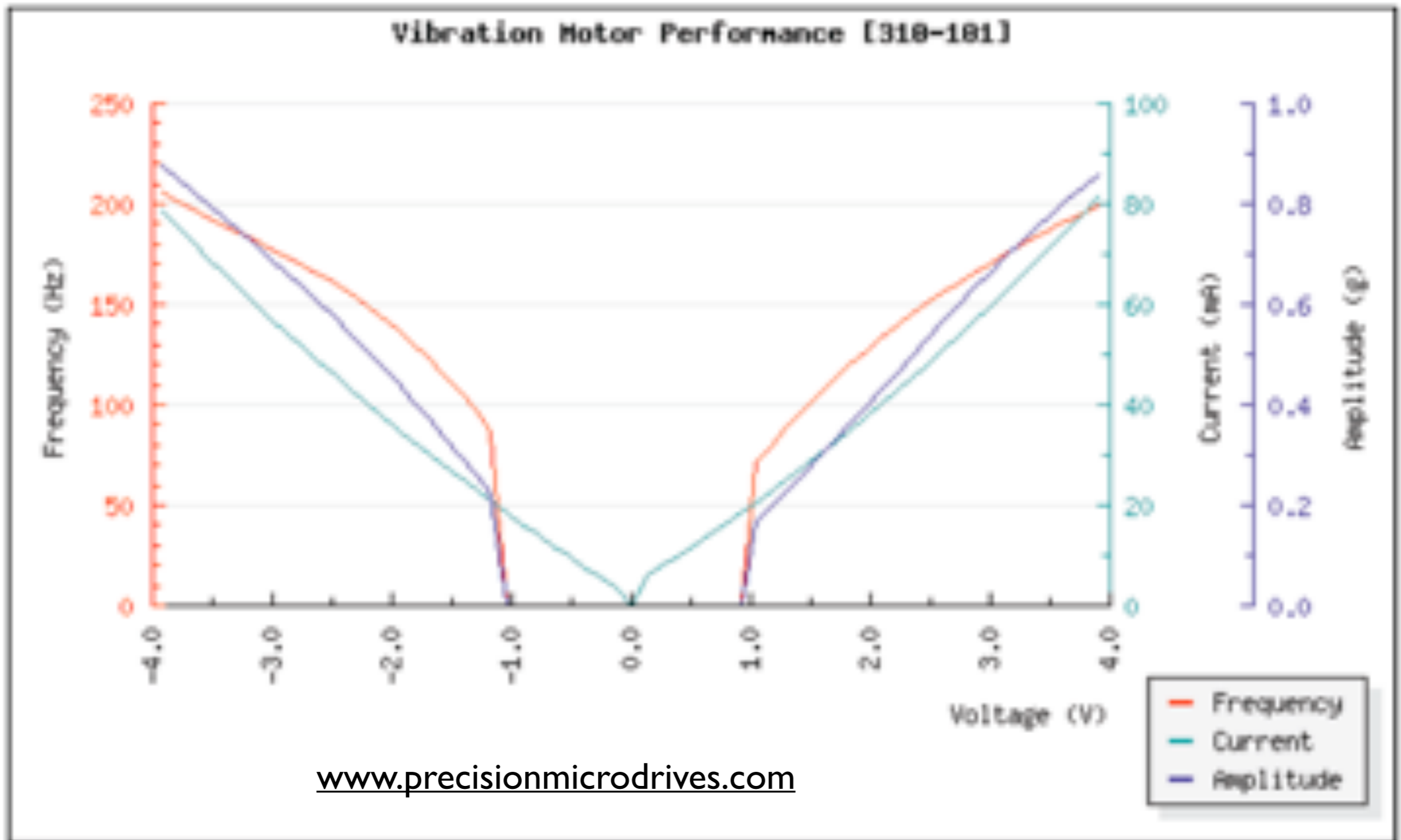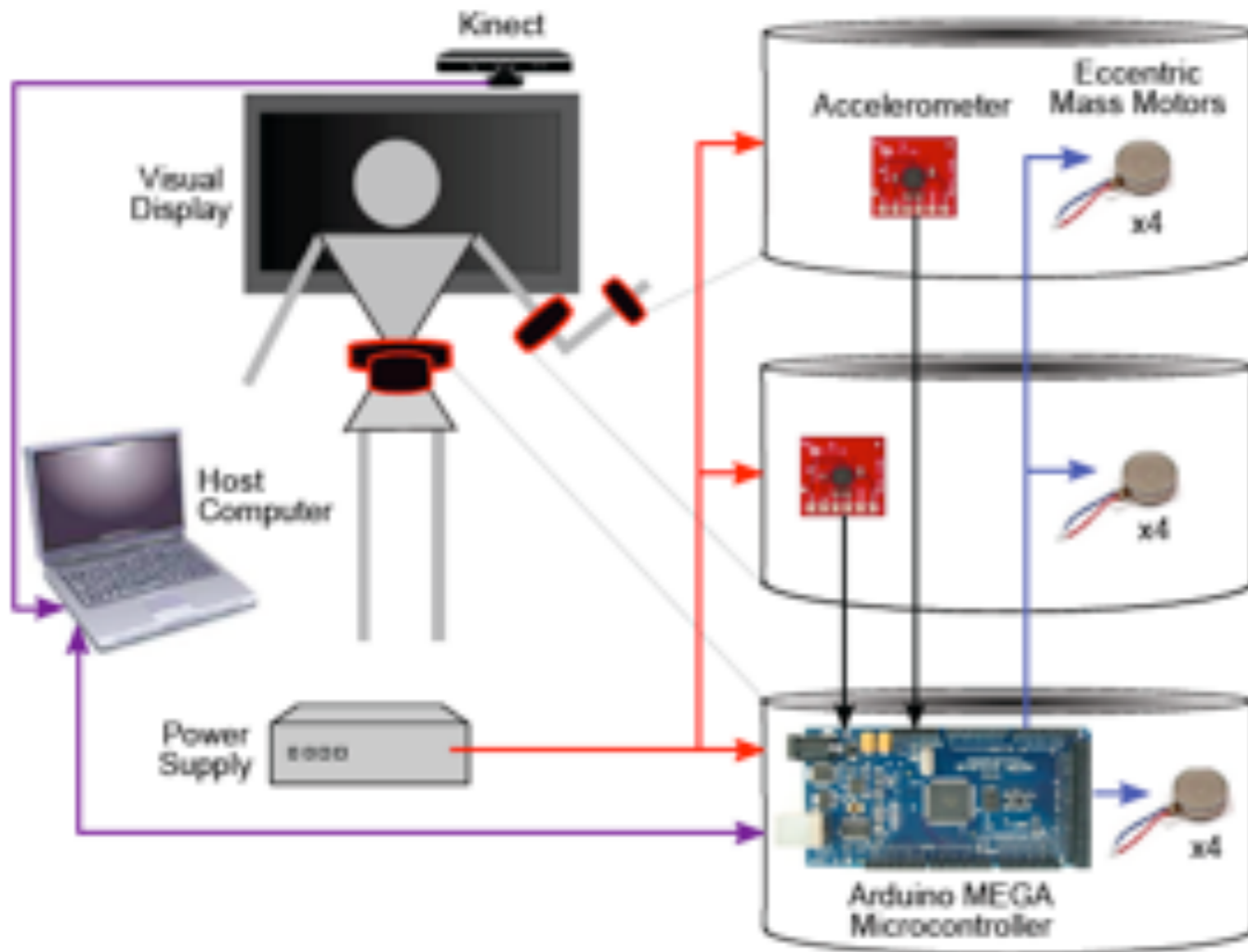
shaftless vibration motors

www.precisionmicrodrives.com
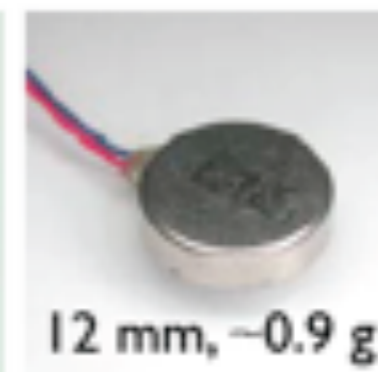
information display
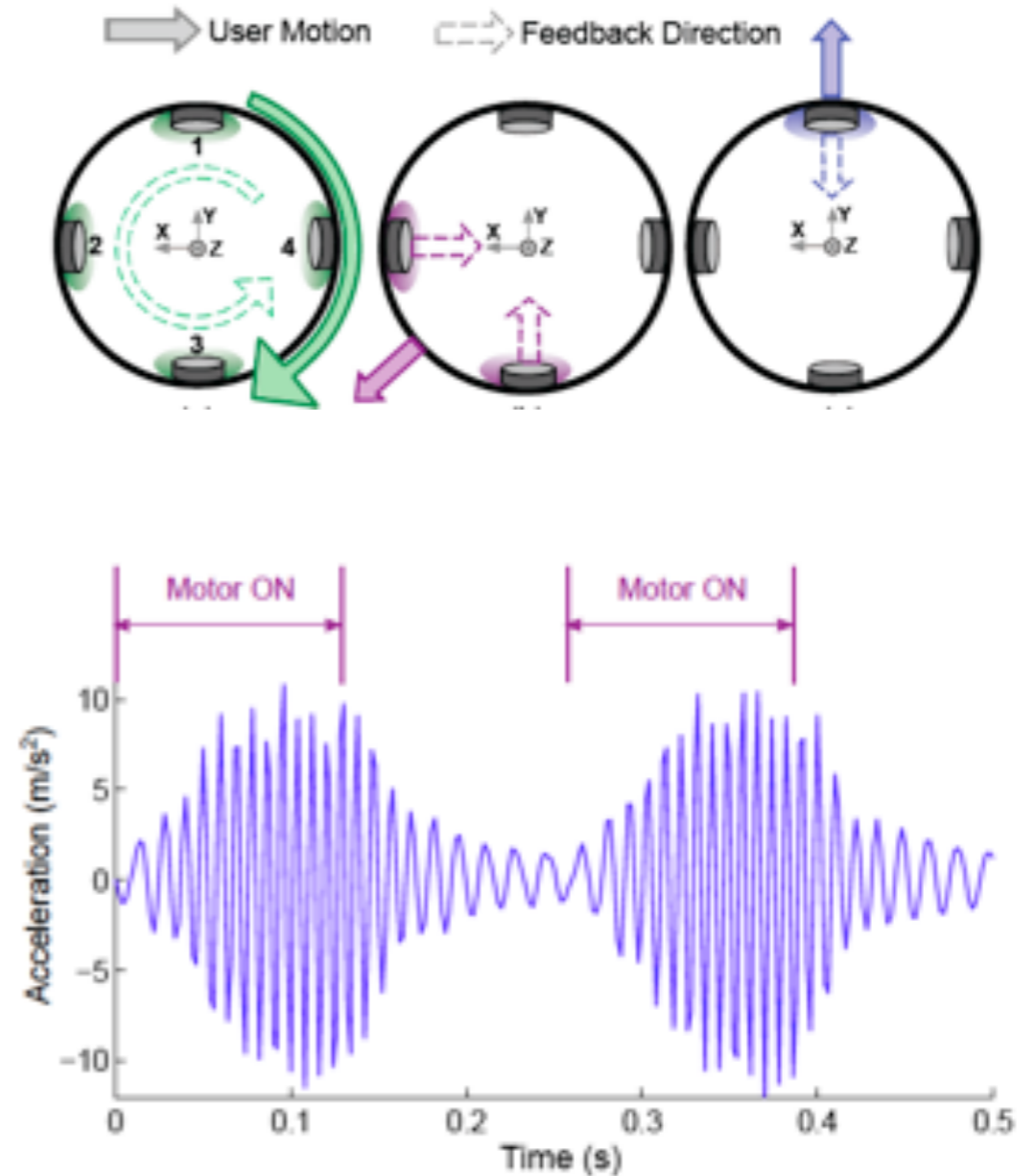
Rotella et al. 2012

linear actuator: C2 Tactor

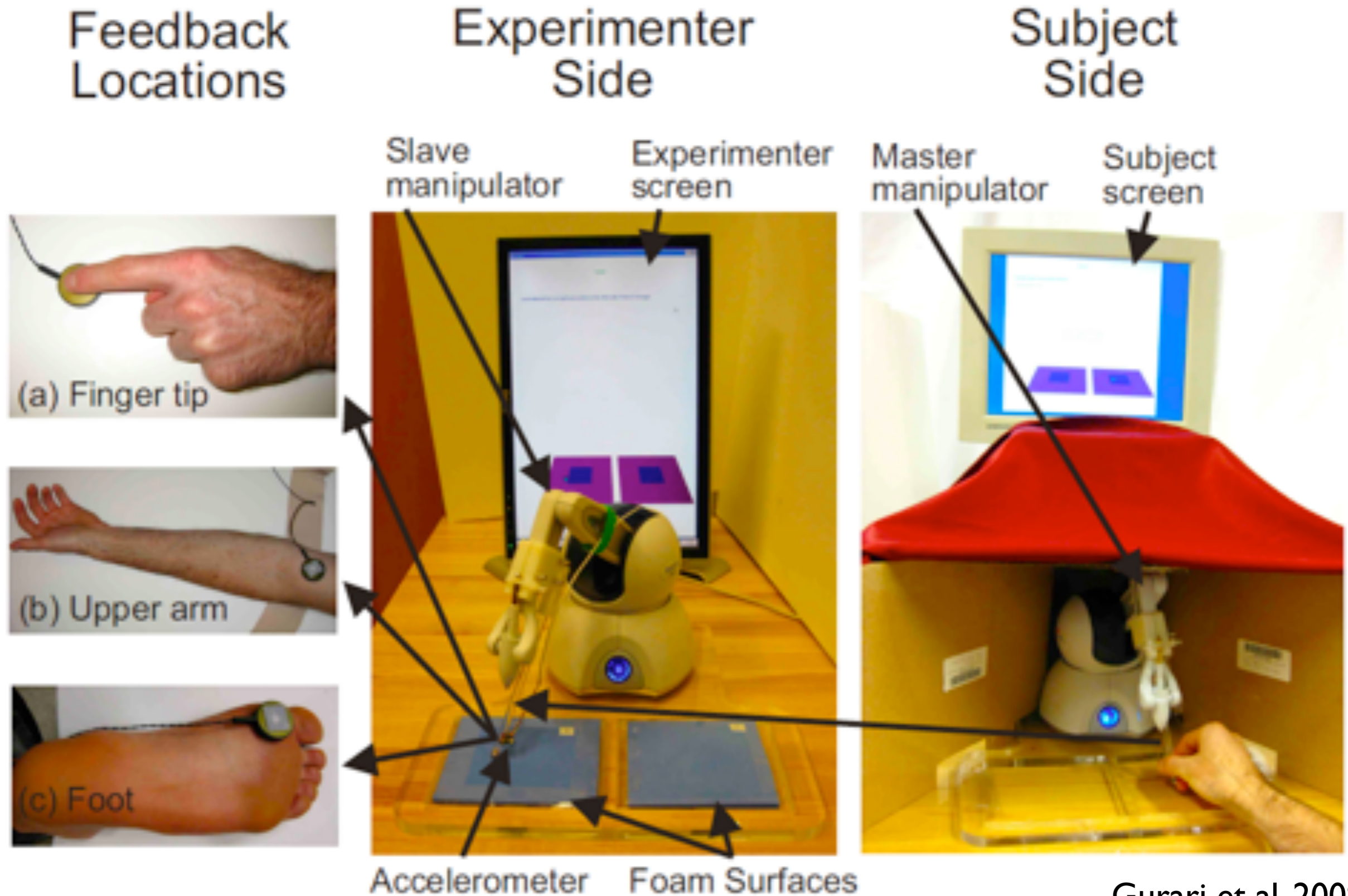Contactor

Housing

SPECIFICATIONS: C-2 TACTOR

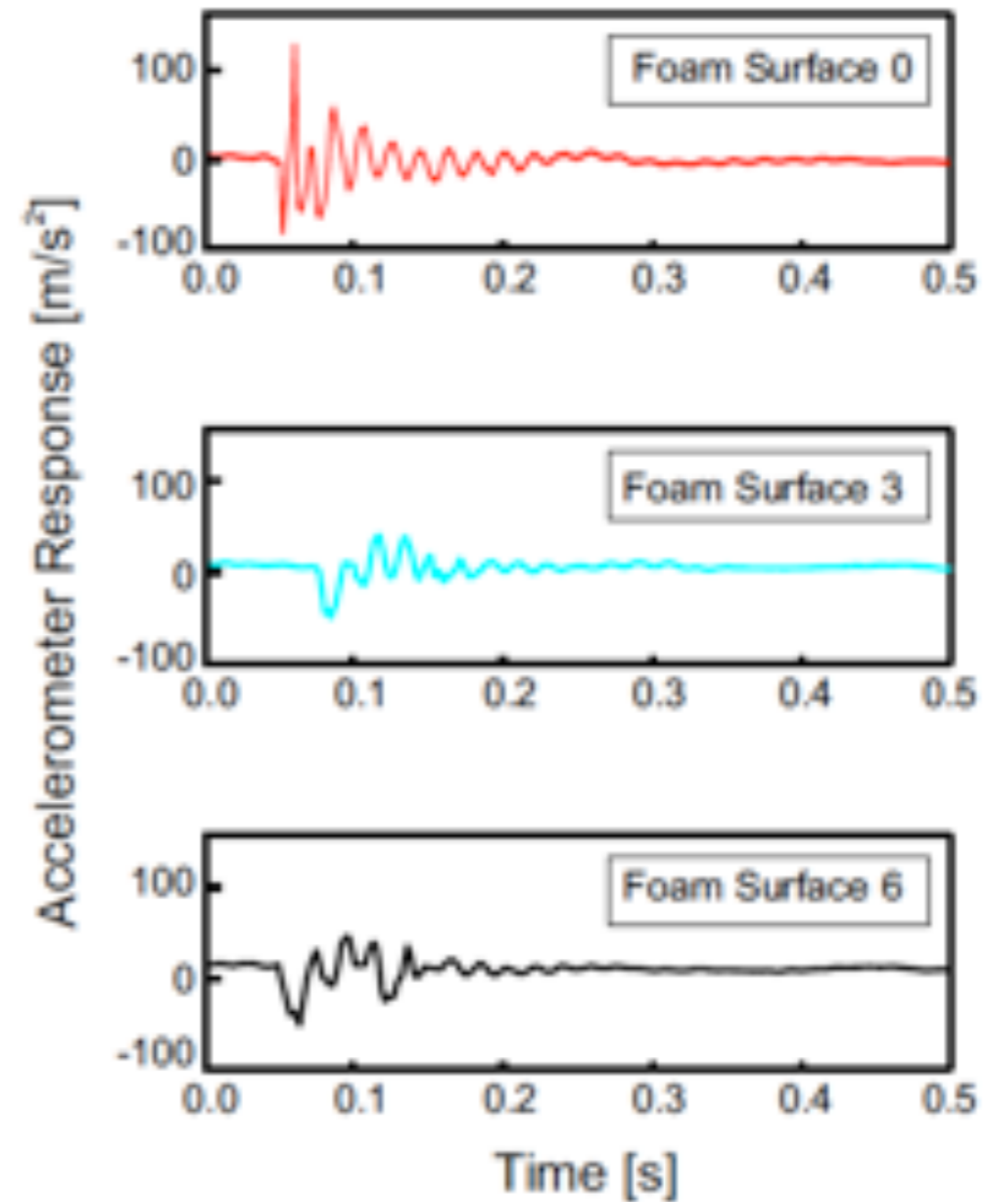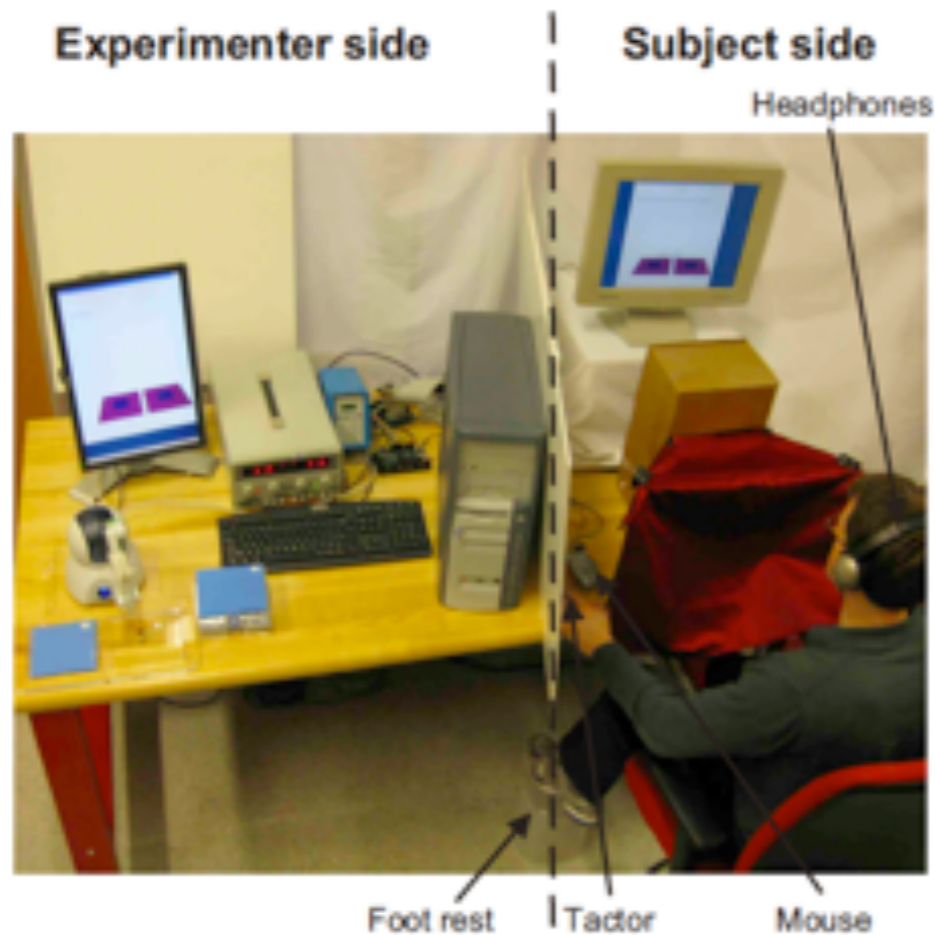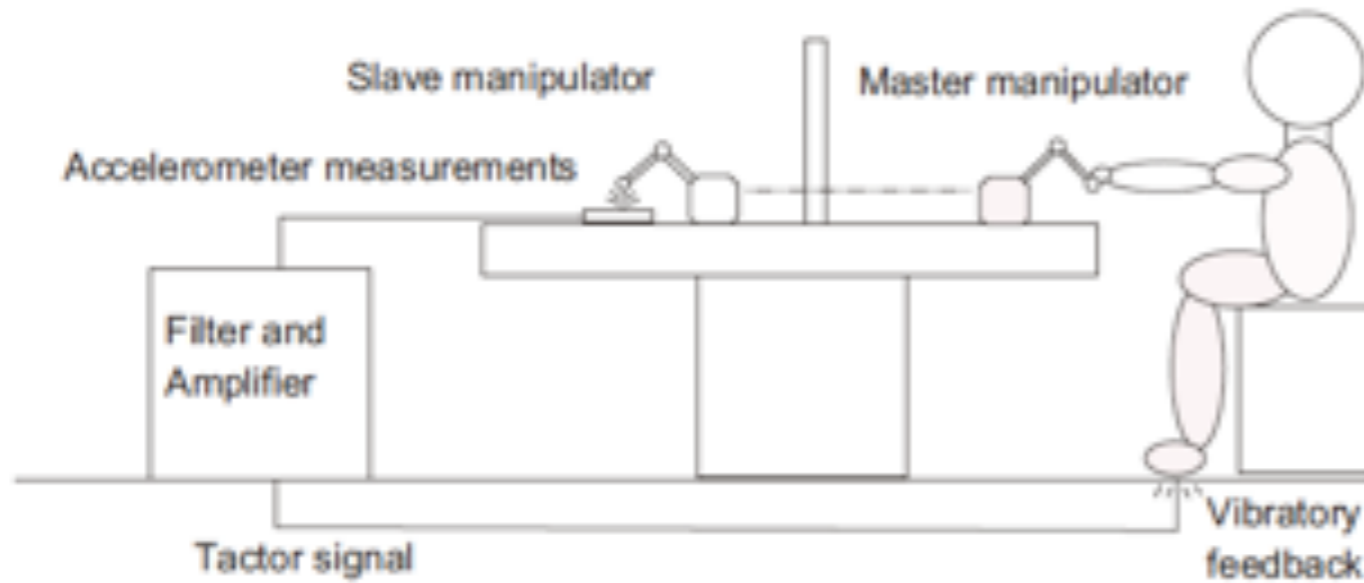|	
Physical Description:	1.2" diameter by 0.31" high
Weight:	17 grams
Exposed Material:	anodized aluminum, polyurethane
Electrical Wiring:	Flexible, insulated, #24 AWG.
Skin Contactor:	0.3" diameter, pre-loaded on skin.
Electrical Characteristics:	7.0 ohms nominal.
Insulation Resistance:	50 megohm minimum at 25 Vdc, leads to housing.
Response Time:	33 ms max
Transducer Linearity:	+/- 1 dB from sensory threshold to 0.04" peak displacement.
Recommended Drive:	Sine wave tone bursts 250Hz at 0.25A rms nominal, 0.5 A rms max for short durations.
Recommended Driver:	Bipolar, linear or switching amplifier, 1 W max, 0.5 W typical.

www.eaiinfo.com

C2 Tactor application

Feedback Locations — (a) Finger tip, (b) Upper arm, (c) Foot

Experimenter Side — Slave manipulator, Experimenter screen, Accelerometer, Foam Surfaces

Subject Side — Master manipulator, Subject screen

Gurari et al. 2009

C2 Tactor application

Gurari et al. 2009

C2 Tactor application

tactor mapping

- Grouped Finger Motions
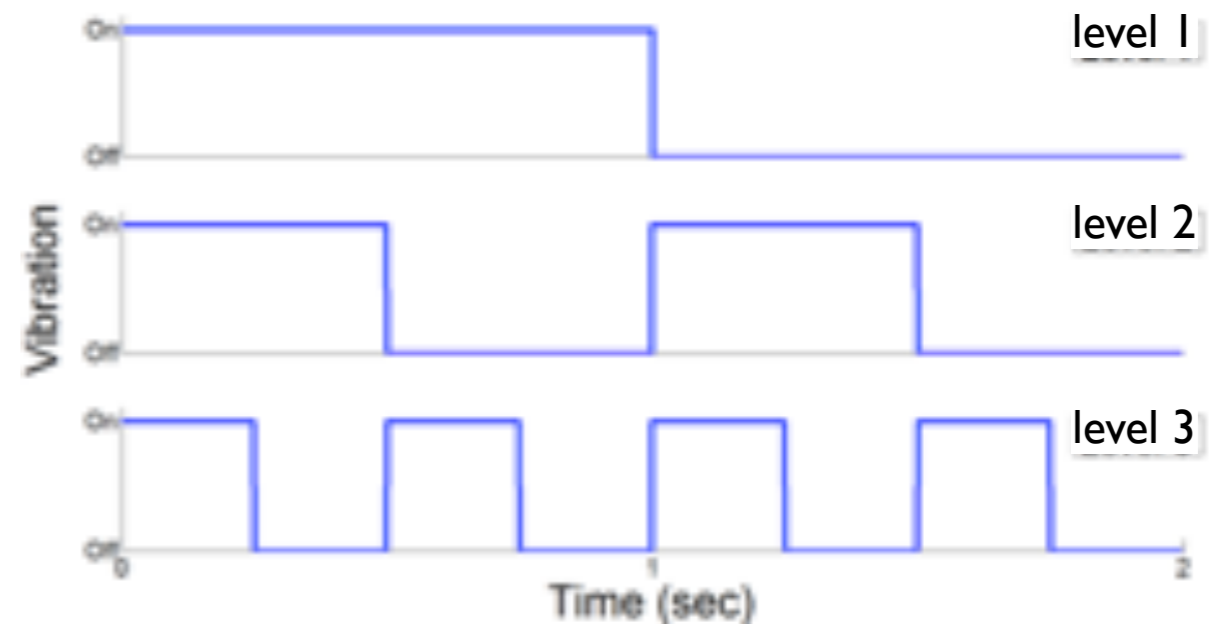- Thumb-Only Motions
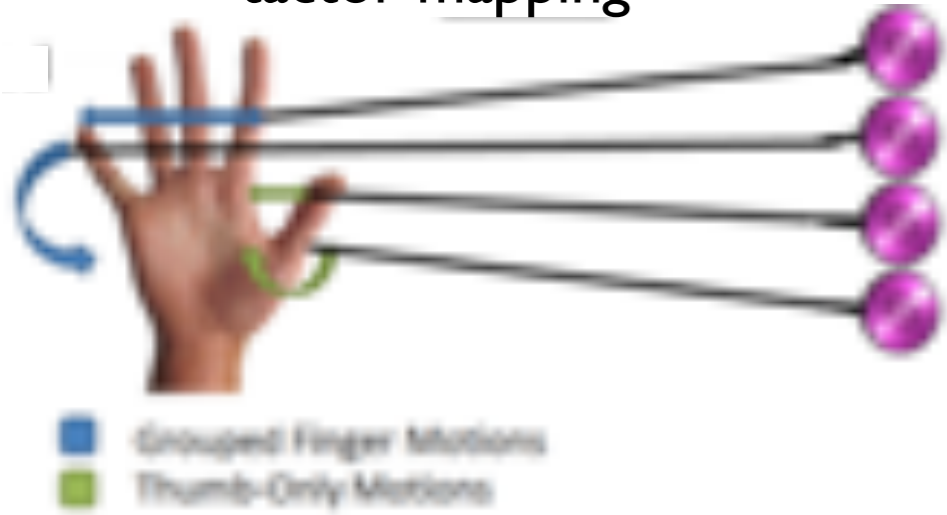
tactor waistbelt

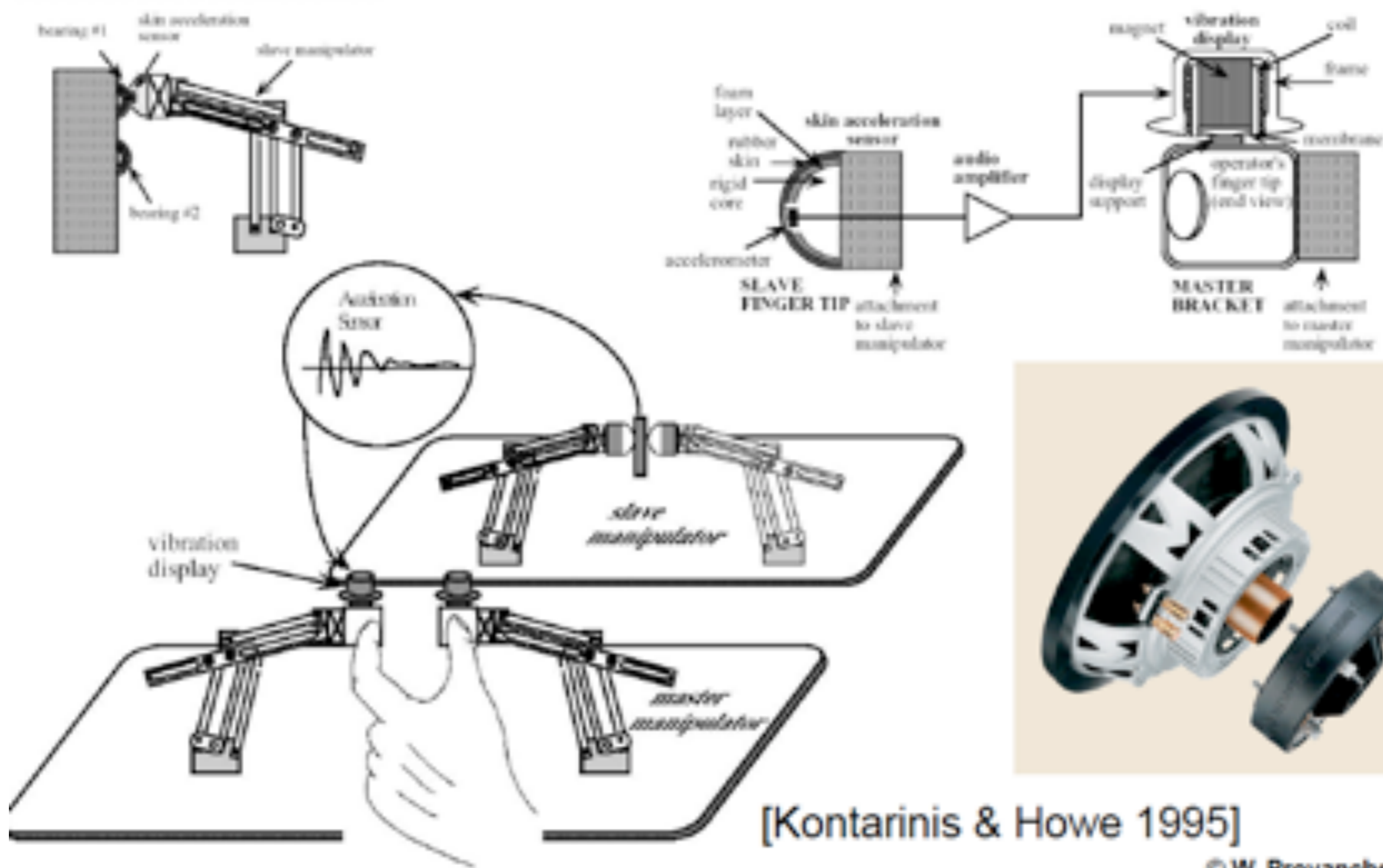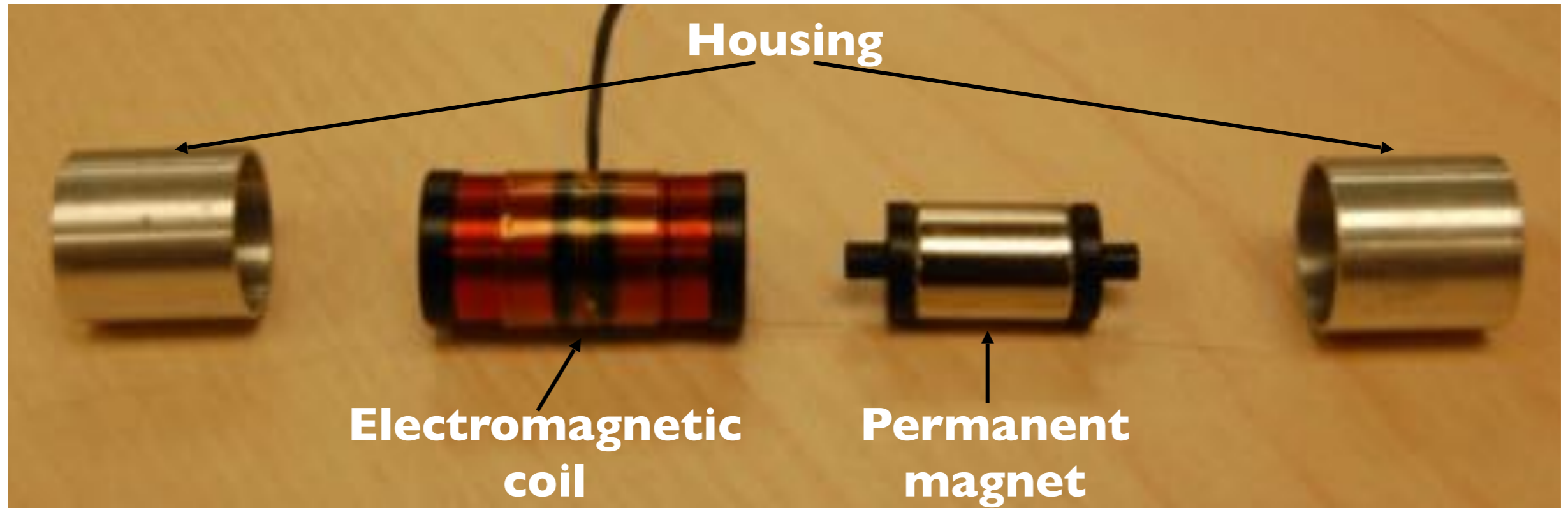virtual prosthetic hand

envelope frequencies

Cheng et al. 2012

Vibrotactile + Force Feedback

[Kontarinis & Howe 1995]
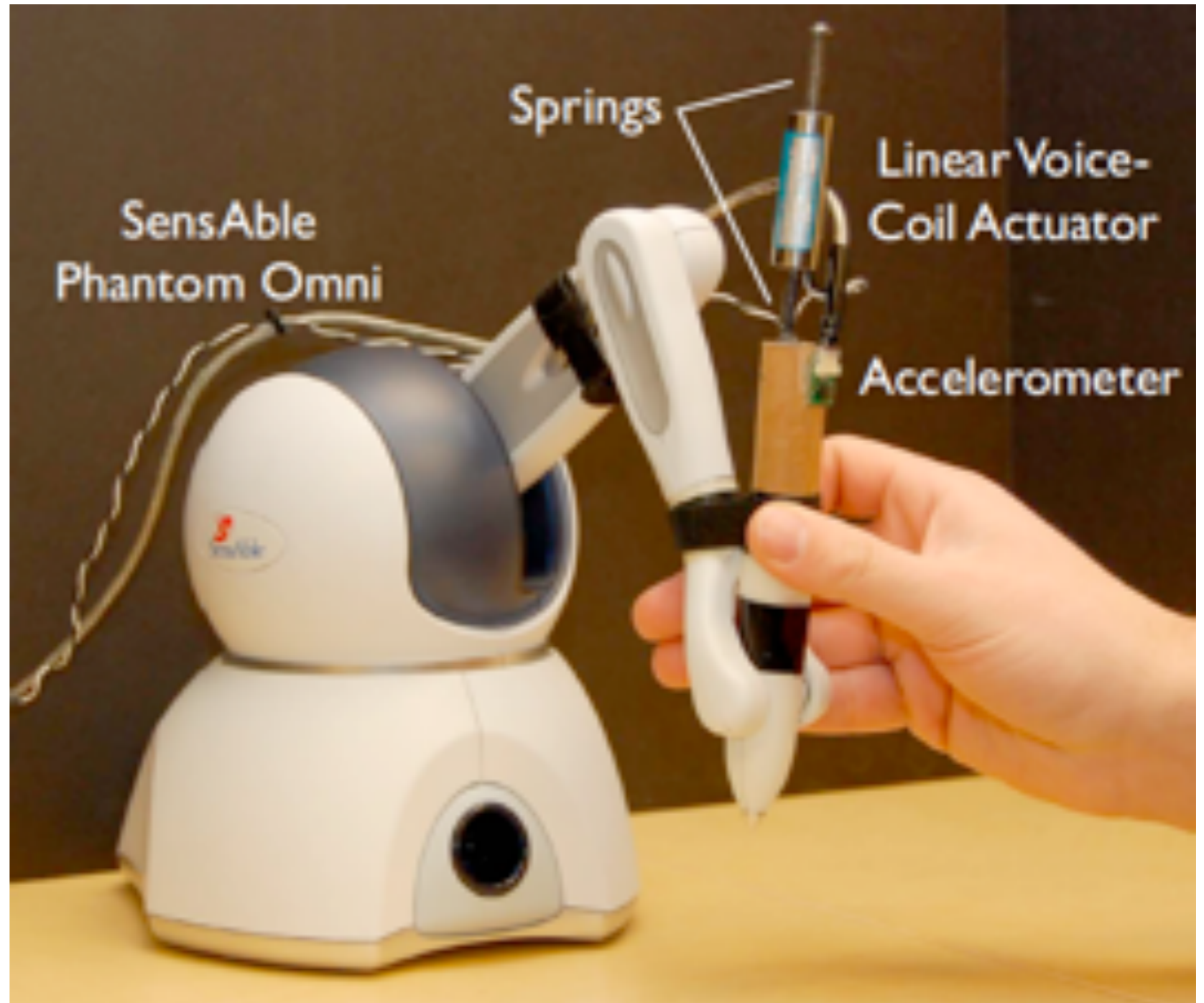
© W. Provancher 2009
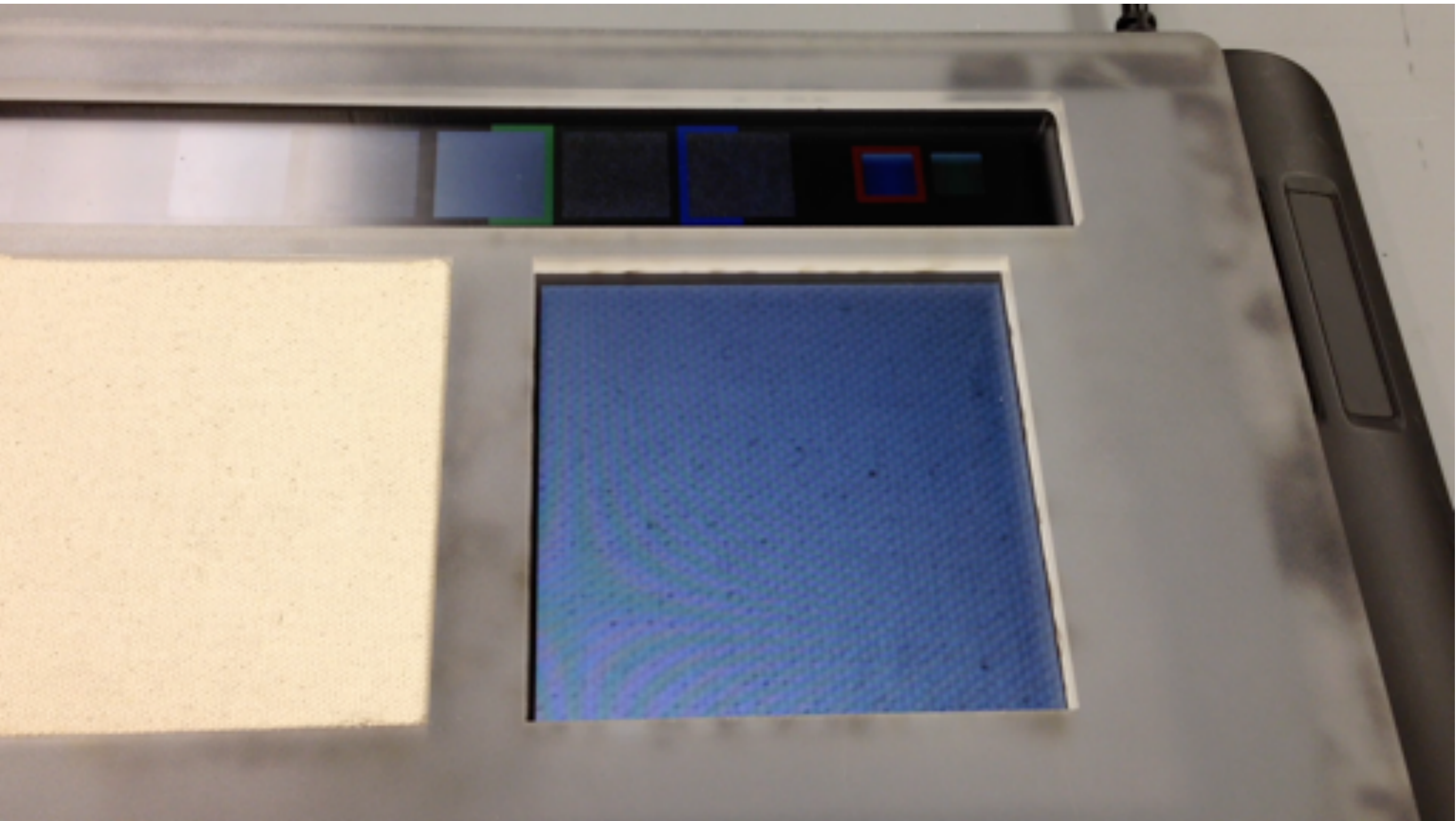
another vibration actuator (voicecoil)

Housing

Electromagnetic coil

Permanent magnet

Haptuator, www.tactilelabs.com

Voicecoil actuator

McMahan and Kuchenbecker 2009

Voicecoil actuator application

Culbertson et al. 2013